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ABSTRACT

In this study, two rival accounts of the mental operations used to solve Piaget's three-mountain perspective task are tested. One hypothesis is that if children use some form of mental rotation through anticipatory imagery, scores should improve as the angle of separation between the child and the other viewer is decreased. A second hypothesis is that if children simply construct a linguistic description of the view adjacent to the other viewer, scores should instead reflect the complexity of the linguistic description of the other's view. In addition, if a linguistic strategy is used, a linguistic response mode should optimize correct responses; if an imagery solution is employed, a non-linguistic response mode would presumably be more appropriate. A total of 120 children in grades K, 2 and 4 were asked to identify another's view either verbally or by picture selection. Results indicate that the verbal response mode leads to substantially more correct responses (82% vs. 45%) and has a minimum of egocentric errors (4% vs. 38%). Correct responses in both verbal and pictorial modes are shown to increase as a function of the linguistic complexity, not the angle of separation. It is suggested that the egocentric perspective errors noted by Piaget can be seen as the by-product of a non-linguistic response mode which does not map onto the linguistic mental operations typically used to solve the task. Spatial egocentrism emerges as a function of one particular mode of response (pictorial) rather than as a general characteristic of pre-operational thought. Analogously, perspective taking seems better described as the handling of increasingly complex linguistic descriptions rather than as a simple "present/absent" phenomenon. (Author/MS)

Children's Ability to Coordinate Spatial Perspectives Through Linguistic Descriptions[1]

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[1] Footnote to cover sheet:

The research reported in this article is part of a Ph.D. dissertation submitted to the University of Toronto, 1976. The preparation of the article was supported in part by a National Institute of Education Grant (G-00-3-0169) to Harvard Project Zero. An extended version of this paper will appear in D.R. Olson and E. Bialystock (Eds.), Explorations in Inner Space: Aspects of the Nature and Development of Spatial Cognition (in preparation).

Introduction

Within experimental psychology one can discern a division between two broad categories which has traditionally been made either implicitly or explicitly in most research dealing with cognitive processes. This dichotomy is generally characterized as a distinction between visual-spatial processes and verbal-semantic processes. Psychologists have generally assumed that items in their intelligence tests and experimental tasks say something about these verbal and spatial processes and that the symbolic mode in which a problem is couched (linguistic or pictorial) determines the processes used to solve the problem. Thus what is called verbal reasoning is tested through verbal means and visual-spatial skills are tested through pictorial means.

Recent research, however, has called these assumptions into question. For example, on the one hand, Kosslyn (1976) has shown that a verbally presented problem such as the question "Does a cat have claws?" can be solved through the propositional, associative processes generally called verbal reasoning or through the construction of a spatial image which has the characteristics of a continuous, analog representation of the problem. On the other hand, David Olson and others (i.e., Olson, 1973; Scher, 1976) have shown that certain visually presented spatial problems are solved through structural, linguistic-like descriptions such as "up to the right" while Roger Shepard and others (i.e., Shepard & Metzler, 1971; Marmor, 1975), have shown that other spatial problems are solved through the use of continuous, analog representations. Thus the fact that a problem has been presented in a certain medium of form does not insure that the mental operations used by the individual will honor the verbal or spatial medium. Nor does it appear that the dichotomy between verbal and spatial processes captures the distinctive operations involved in problem solving. Certain verbal and spatial problems can be solved through the use of continuous, analog representations while others are solved through structural, linguistic descriptions. Moreover, it appears likely that some verbal and spatial problems can be solved through either continuous or structural representations (Collins & Quillian, 1972; Jorgensen & Kintch, 1973; Olson, 1973; Quinton & Fellows, 1975) and that different individuals might approach the same problem through different mental operations (Gardner, 1977; Gardner, Wolf, & Smith, 1975; Kosslyn, 1976; Quinton & Fellows, 1975; Wolf & Gardner, 1977). To further clarify some of these issues this paper will explore one of the classic examples of spatial problem solving, Piaget's three mountain task (Piaget & Inhelder, 1956). The present investigation of spatial perspective taking will focus on both the role of symbolic representation in problem solving and the mental operations underlying the child's solution to the task.

Spatial Perspective Taking

In one of the most cited experiments in developmental psychology, Piaget and Inhelder (1956) presented children ages 4 through 12 with an array of three mountains in order to test their ability to coordinate spatial perspectives. Children younger than 7 tended to choose the picture identical to their own view rather than that of the other viewer. Piaget and Inhelder attributed this failure to distinguish between viewpoints to the child's egocentrism; it was not until age 9 or 10 that the child could successfully coordinate the perspectives involved in the three mountain task.

Subsequent research, however, has shown that with modifications in the experimental design children as young as two and a half can correctly choose another's view (Masangkay, McCluskey, McIntyre, Sims-Knight, Vaughn, & Flavell, 1974) and the number of egocentric errors can be greatly reduced (Borke, 1975; Keilgast, 1971), thus indicating that the ability to coordinate spatial perspectives is not simply a present/absent phenomenon. However, the exact relationship between the initial abilities of young children to solve simple perspective tasks and the skills required to solve the more difficult three mountain task remains to be formulated since an understanding of what constitutes complexity in a perspective task requires a knowledge of the underlying mental operations involved in its solution.

Few of the many perspective studies have dealt with these underlying mental operations and in those which do it has simply been assumed that some form of mental imagery is involved in the solution (De Lisi, Locker, & Youniss, 1976; Harris & Bassett, 1976; Huttenlocher & Presson, 1973; Nigl & Fishbein, 1974). However, two rival accounts can be hypothesized. The child can possibly use some for of mental rotation by the means of anticipatory imagery and continuous representations. If so, then some form of analog relationship or "second order isomorphism" (i.e., Shepard, Kilpatric, & Cunningham, 1975; Shepard & Metzler, 1971) should occur between the internal mental operations and the external act of taking another's spatial view as has been shown in an increasing amount of research involving mental imagery. Therefore, perspective taking scores should improve as the angle of separation or the rotational distance between the child and the other viewer is decreased.

If, on the other hand, children simply construct a structural, linguistic description of the view in front of the other viewer, scores should reflect not the rotational distance but rather the complexity of the structural description of the other's view. In this account the "side" or "back" of a car, for example, should be easier to indicate than the front corner which requires a more complex description. Furthermore, referent objects which contain an inherent "side" or "back" such as a car should simplify the assignment of a linguistic description. Referent displays like the three mountains which have no inherent structural descriptions need to be described in terms of the relationship between objects such as "the red mountain is in front of the yellow mountain" and therefore will add more complexity to the task. In addition, if a structural, linguistic description is used in the perspective task, a linguistic response mode should optimize correct responses; if an anticipatory imagery solution is employed, a non-linguistic, continuous response mode such as pictures would presumably be more appropriate.

In order to test these competing accounts the following experiment was conducted.

Experimental Procedures

Participants

One hundred and twenty public school children attending Kindergarten, Grade Two and Four in Scarborough, Ontario were individually tested.

Materials

Four toy objects with inherent structural descriptions (car, man, house, horse) hereafter called canonical objects, and a two-thirds replica of Laurendeau and Pinard's (1970) three mountain display were used as the referents in the task. A black 35 mm. camera was used to mark the "other" viewpoint in all instances.

Procedures

Twenty children per grade were tested on their ability to indicate another's view in each of two response conditions: picture selection and verbal response. In a practice trial using a toy boat and again with each referent children were trained on either the correspondence of the pictures with their appropriate orientation or the verbal label for each possible correct orientation. The verbal labels for the three mountain display were: "red in front of yellow," etc. Ten basic combinations of object orientation and camera placement (hereafter simply called orientation) were chosen to allow the camera to be placed in positions of 45°, 90°, 135°, and 180° from the child's position and to also allow the correct linguistic response to be the front, back, side, front corner, and back corner orientations for each referent object. The camera placement and the orientation of the object were manipulated independently and each child received five of the ten orientations for each of the five referents in a counterbalanced manner.

Results and Discussion

The Three Mountain Display Condition. A summary of the findings from the three mountain condition is presented in this first slide (Table 1). While the results from the picture selection condition include more correct responses than found in Laurendeau and Pinard's tasks from which the stimulus was taken because of such factors as the practice trial, the basic trend of the correct responses and egocentric errors is replicated. However, while the picture selection condition has only a 38% correct response rate across grade levels, 79% of the verbal responses are correct ($F_{(1,18)}=120.93$, $p<.001$). The response condition effect is highly significant and it accounts for 62% of the variance. In addition, there is a 32% egocentric response rate across grade levels in the picture selection condition but only a 10% egocentric rate in the verbal condition, again a highly significant difference ($F_{(1,18)}=75.28$, $p<.001$).

As slide 1 (Table 1) indicates the correct scores of children in both response conditions increase with grade level ($F_{(2,18)}=20.18$, $p<.001$) in a significant linear trend ($F_{lin(1,18)}=40.33$, $p<.001$) and grade level accounts for 20% of the variance. The orientation main effect for correct responses is not significant ($p>.10$) since the number of correct responses does not vary as the result of a change in the rotational distance nor is there any significant variation as a result of a change in the description of the other's view. However, within the three mountain condition there is no variation in the linguistic complexity of each correct description.

The three mountain results thus imply that children generally solve the task by assigning structural, linguistic descriptions to the array rather than by mentally rotating the array. Spatial egocentrism appears to be related to one particular mode of response (the pictorial) rather than to a general characteristic of pre-operational thought. Stronger evidence to support these contentions is seen in the results of the canonical object condition.

The Canonical Object Condition. A second slide (Table 2) shows the canonical object results. The object effect was insignificant in all analyses ($p > .10$) so that all generalizations will be made across objects. The grade level effect is again significant ($F_{(2,54)} = 132.76$, $p < .001$) primarily reflecting a linear increase of correct responses with increasing grade level ($F_{lin(1,54)} = 264.53$, $p < .001$). In the verbal response condition 83% of the total responses are correct while only 47% are correct in the picture selection condition and the significant response condition effect ($F_{(1,54)} = 594.12$, $p < .001$) accounts for 41% of the variance. Only 3% of the verbal responses are egocentric while 40% of the picture selection responses are egocentric with the significant response condition effect ($F_{(1,54)} = 721.46$, $p < .001$) accounting for 58% of the variance in the analysis of egocentric errors. There is no systematic decrease in correct responses with an increase in the rotational distance as might be predicted by an anticipatory imagery solution.

On the other hand, as the second slide shows, the linguistic complexity of the correct response does have an effect on correct responses and a planned comparison indicates that this difference is significant ($F_{simple\ vs.\ complex(1,54)} = 194.85$, $p < .001$). Further comparisons of correct responses also demonstrate that the complexity of the correct linguistic description affects the child's ability to solve the perspective task but time does not permit complete coverage.

A detailed analysis of the error patterns also indicates that the complexity of the structural description influences the type of response and that each mode of response has its own characteristic error pattern. This is particularly evident in the kindergarten responses as seen in Table 2. In both response conditions orientations with complex structural descriptions result more in correct responses. However, each mode of response has its own error pattern. Picture selection results in more egocentric errors (53% vs. 8%) and verbal responses result in more non-egocentric errors (50% vs. 25%). When the correct orientation requires a two-part linguistic label (for example, "front and side" which was the term used for front corner) kindergarten children tended to leave off one component of this description. For example, instead of saying "front and side" the child would simply respond with "front" or "side" and this type of error accounts for 96% of the non-egocentric kindergarten errors in the verbal condition seen in the second slide (Table 2).

We are now able to see that development in perspective taking can be described as the ability to handle increasingly more complex structural descriptions of the other's viewpoint. Complexity in perspective taking can now be defined as a function of the features of a referent, that is, whether or not is has inherent structural descriptions and as a function of the type of relationship between the referent and the other viewer, that is, whether or not the other's view maps directly on to one of the inherent structural descriptions. The results of the canonical object condition also confirm the finding of the three mountain condition that spatial egocentrism in perspective taking appears related to the pictorial mode of response rather than to a general characteristic of pre-operational thought and the results also support the contention (Olson, 1976) that each means of response has its own characteristic error pattern.

Conclusion

The results reported in this paper clearly support the position that difficulty in the perspective task is a function of the complexity of the structural description assigned to the other's view and the degree to which the means of response maps on to those structural descriptions. However, I do not wish to convey the impression that the solution to all spatial problems lies simply in an ability to verbalize or that language is the key to all understanding. The use of spatial imagery through continuous, analog representations is well documented by Roger Shepard and others (Kosslyn and Pomerantz, 1977). What does seem to be emerging in recent research is the finding that many spatial problems which were traditionally assumed to be solved through anticipatory imagery and continuous analog representations are actually organized and solved through structural descriptions. Moreover, it seems that the dichotomy between verbal and spatial might more accurately be characterized as a distinction between the use of continuous and/or structural descriptions for both verbal and spatial problems. As Olson and others have stated, the use of structural descriptions cuts across verbal and visual representations and, taken together, the work of Kosslyn, Shepard and others indicates that the use of continuous representations can occur in both verbal and visual presentations. In addition Marmor and Zaback (1976) have shown that congenitally blind adults solve tactilely presented rotation problems using the same type of continuous, analog representations as sighted adults thus providing evidence that mental rotation is not dependent on visual imagery but rather the use of continuous representations.

Some problems such as mentally rotating a spatial array (Shepard & Metzler, 1971) or unfolding a cube (Shepard & Feng, 1972) seem particularly suited for continuous representations. Others such as determining another's perspective or comparing the orientation of two lines (Olson, 1973) are particularly suited for structural descriptions. A third set of problems such as determining the truth of descriptive statements (Kosslyn, 1976), solving analogies (Olson, 1973) or three-term series problems (Quinton & Fellows, 1975), understanding a poem (Gardner, 1977), organizing verbal narratives, constructing maps, and dealing with certain mathematical principles are perhaps subject to solution through either continuous or structural descriptions. It may, in fact, be that most problems fall on a continuum as to the applicability of continuous or structural descriptions. In addition, it may be that individuals also fall somewhere on a continuum as to their preference and skill in using continuous or structural descriptions when approaching problems.

If the above speculations prove correct, then the task of the psychologist and the educator is to move beyond the visual-verbal dichotomy, determine the skills actually necessary to solve particular tasks, and devise training strategies to fit both the nature of the task and the preference and skills of individuals. Children who lack the intuitive ability to efficiently utilize either structural or continuous representations could be trained directly in their deficient skill as Salomon (1974) has done with film modelling of "zooming in" on details. Moreover, depending on the requirements of the task, children could be shown how to use their preferred skills to reach a solution in an area in which they were formerly deficient. If children of low spatial ability can be taught to utilize structural descriptions in the organization of space and children of low-verbal ability can be taught to utilize continuous representations in the organization of verbal material, then their particular cognitive strengths might not be a limiting factor in the range of problems they can master and subsequently in the occupations in which they are potentially skillful.

References

Borke, H. Piaget's mountains revisited: Changes in the egocentric landscape. Developmental Psychology, 1975, 11, 240-243.

Collins, A.M., & Quillian, M.R. Experiments on semantic memory and language comprehension. In L.C. Gregg (Ed.), Cognition in learning and memory. New York: Wiley, 1972.

Cooper, L.A., & Shepard, R.N. Chronometric studies of the rotation of mental images. In W.G. Chase (Ed.), Visual information processing. New York: Academic Press, 1973.

De Lisi, R., Locker, R., & Youniss, J. Anticipatory imagery and spatial operations. Developmental Psychology, 1976, 12, 298-310.

Gardner, H. Senses, symbols, operations: An organization of artistry. In D. Perkins & B. Leondar (Eds.), The arts and cognition. Baltimore: Johns Hopkins University Press, 1977.

Gardner, H., Wolf, D., & Smith, A. Artistic symbols in early childhood. New York University Education Quarterly, 1975, 6, 13-21.

Harris, P.L., & Bassett, E. Reconstruction from the mental image. Journal of Experimental Child Psychology, 1976, 21, 514-523.

Huttenlocher, J., & Presson, C.C. Mental rotation and the perspective problem. Cognitive Psychology, 1973, 4, 277-299.

Jorgensen, C.C., & Kintch, W. The role of imagery in the evaluation of sentences. Cognitive Psychology, 1973, 4, 110-116.

Kielgast, K. Piaget's concept of spatial egocentrism: A re-evaluation. Scandinavian Journal of Psychology, 1971, 12, 179-191.

Kosslyn, S.M. Using imagery to retrieve semantic information: A developmental study. Child Development, 1976, 47, 434-444.

Kosslyn, S.M., & Pomerantz, J.R. Imagery, propositions, and the form of internal representations. Cognitive Psychology, 1977, 9, 52-76.

Laurendeau, M., & Pinard, A. The development of the concept of space in the child. New York: International Universities Press, 1970.

Marmor, G.S. Development of kinetic images: When does the child first represent movement in mental images? Cognitive Psychology, 1975, 7, 548-559.

Marmor, G.S., & Zaback, L.A. Mental rotation by the blind: Does mental rotation depend on visual imagery? Journal of Experimental Psychology: Human Perception and Performance, 1976, 2, 515-521.

Masangkay, Z., McCluskey, K., McIntyre, C., Sims-Knight, J., Vaughn, B., & Flavell, J. The early development of inferences about the visual percepts of others. Child Development, 1974, 45, 357-366.

Nigl, A.J., & Fishbein, H.D. Perception and conception in coordination of perspectives. Developmental Psychology, 1974, 10, 858-866.

Olson, D.R. On the relations between spatial and linguistic processes. In, Children's spatial development: New research orientations. Springfield, Ill.: Charles C. Thomas, 1973.

Olson, D.R. Towards a theory of instructional means. Educational Psychologist, 1976, 12, 14-35.

Piaget, J., & Inhelder, B. The child's concept of space. New York: Norton Press, 1956.

Quinton, G., & Fellows, B.J. "Perceptual" strategies in the solving of three-term series problems. British Journal of Psychology, 1975, 66, 69-78.

Salomon, G. Internalization of filmic schematic operations in interaction with learner's aptitudes. Journal of Educational Psychology, 1974, 66, 499-511.

Scher, A. Children's mental representation of oblique orientation. Unpublished masters dissertation, University of Toronto, 1976.

Shepard, R.N., & Feng, C. A chronometric study of mental paper folding. Cognitive Psychology, 1972, 3, 228-243.

Shepard, R.N., Kilpatric, D.W., & Cunningham, J.P. The internal representation of numbers. Cognitive Psychology, 1975, 7, 82-138.

Shepard, R.N., & Metzler, J. Mental rotation of three-dimensional objects. Science, 1971, 171, 701-703.

Wolf, D., & Gardner, H. Style and sequence in early symbolic play. To appear in N. Smith (Ed.), Early symbolization, 1977, in preparation.

EXPERIMENT ONE

RESULTS OF THE PERSPECTIVE TASK USING THE THREE MOUNTAIN DISPLAY

GRADE AND CONDITION:	CORRECT RESPONSE	EGOCENTRIC ERROR	NON-EGOCENTRIC ERROR
<u>KINDERGARTEN</u> (5.5)			
PICTURE SELECTION	25	36	39
VERBAL RESPONSE	64	13	23
<u>GRADE TWO</u> (7.4)			
PICTURE SELECTION	35	32	33
VERBAL RESPONSE	82	12	06
<u>GRADE FOUR</u> (9.8)			
PICTURE SELECTION	55	29	16
VERBAL RESPONSE	92	05	03

Table One

(Figures represent percentages)

Table Two
(Figures represent percentages)

EXPERIMENT ONE
RESULTS OF THE PERSPECTIVE TASK USING CANONICAL OBJECTS

GRADE AND CONDITION:	CORRECT RESPONSE		EGOCENTRIC ERROR		NON-EGOCENTRIC ERROR	
KINDERGARTEN (5.5)	C	S	C	S	C	S
PICTURE SELECTION	23	46	53	47	25	18
VERBAL RESPONSE	43	86	08	04	50	12
GRADE TWO (7.4)						
PICTURE SELECTION	34	54	50	35	17	11
VERBAL RESPONSE	82	89	03	05	15	07
GRADE FOUR (9.8)						
PICTURE SELECTION	50	74	38	19	11	08
VERBAL RESPONSE	90	98	01	01	10	02

C = COMPLEX DESCRIPTION FOR CORRECT RESPONSE (i.e. "FRONT CORNER")

S = SIMPLE DESCRIPTION FOR CORRECT RESPONSE (i.e. "FRONT")